Data-limited models for informing groundfish management

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90+ species
Longevity: 5-200+

Fishery

- Lat. range: 32°-49° N
- Multiple factors
  - States
  - Sectors
  - Vessels
  - Gear types
- Data
  - Types
  - Quality
  - Quantity
Limitations to conducting stock assessments

- #/diversity of stocks
- Data availability
- Large stock ranges
- Trained analysts
- Reviewers
- Council time
- Maintaining “current” assessments
- General funding
### Informing catch limits

<table>
<thead>
<tr>
<th>Stock category</th>
<th>Default OFL uncertainty</th>
<th>Affiliated assessment type</th>
<th>Data types</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$\sigma=0.36$</td>
<td>Statistical Catch at Age</td>
<td>Catch, detailed life history, indices, length/age comps.</td>
</tr>
<tr>
<td>2</td>
<td>$\sigma=0.72$</td>
<td>Index-based methods</td>
<td>Catch, basic life history, abundance indices</td>
</tr>
<tr>
<td>3</td>
<td>$\sigma=1.44$</td>
<td>Catch-only</td>
<td>Catch, basic life history</td>
</tr>
</tbody>
</table>

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Timeline and context

Years of the Groundfish FMP

Groundfish Fishery Management Plan implemented
- Low data, simple methods (avg catch, YPR, VPA, SRA)
- SS1, average catches for other stocks
- Rogers “ABC = M*B_{avg}” applied to some “remaining rockfish”
- SS2+, average catches for other stocks
- DCAC
- DB-SRA; MSA requirement to end overfishing, set ACLs
- First data-limited methods review panel: DB-SRA and SSS
- Data-limited methods review panel: XDB-SRA and XSSS
- First data-moderate STAR panel: XDB-SRA and XSSS for
- Continued research (e.g., status prior) on data-moderate methods
Methods: Depletion-Corrected Average Catch

DCAC

Sustainable Yield Calculated as:

\[ Harvest = \frac{\sum Catch}{n + \left( \frac{\Delta}{B_{MSY} \cdot B_0 \cdot \frac{F_{MSY}}{M} \cdot M} \right)} \]

where:

- \( n \) is the number of years,
- \( \Delta \) is the relative stock status to starting conditions (\( \Delta = 1 - \text{depletion} \)),
- \( \frac{B_{MSY}}{B_0} \) is the relative stock size where maximum sustainable yield (MSY) occurs,
- \( M \) is natural mortality, and
- \( \frac{F_{MSY}}{M} \) is the ratio of the fishing mortality rate associated with MSY and natural mortality.

MacCall 2009
Methods: Depletion-Based Stock Reduction Analysis (DB-SRA)

\[ B_{t+1} = B_t + P_{t-a} - C_t \]

- Age at maturity
- Catch by year
- Population Model
- \( B_0 \)
- OFL
- MSY
- \( B_{MSY} \)

Dick and MacCall 2010, Dick and MacCall 2011
Simple and extended Stock Synthesis

**SSS & XSSS**

- Priors defined for $M$, $h$, and depletion
- Set-up SS files with catches and indices (XSSS)
- Solve for $\ln R_0$ and extra SD on indices (XSSS)

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*Note: Diagrams showing distributions of neutral mortality, steepness, and stock status.*
Methods: SSS and XSSS protocol: estimation

- Priors defined for M, h, and depletion

\[ N_{\text{final}} \]

SSS

Draw 1 value, solve \( \ln R_0 \)

[Histogram of variable]

SSS: Cope. 2013. Fish Res. 142: 3-14

exSSS: Cope et al. in review. Fish Res

XSSS

Draw \( N_{\text{init}} \); solve \( \ln R_0 \)

Draw \( N_x \); solve \( \ln R_0 \)

Calculate sample weights

Calculate entropy (E)

Weighted \( N_{\text{init}} \) redraw

\[ E < T \]

\[ E > T \]

Student’s-t mvtn = posterior

[Histogram of variable]

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## Extended/Depletion-based Stock Reduction Analysis (X/DB-SRA)

- **Common data** (Catch, indices)
- Selectivity = maturity
- Natural mortality
- Depletion prior
- Delay-difference
- Single-sex
- Growth: none (no SPR)
- Productivity: $F_{\text{MSY}}/M$; $B_{\text{MSY}}/B_0$

## Extended/Simple Stock Synthesis (X/SSS)

- Age-structured
- Two-sex
- VBGF parameters
- Productivity: Steepness ($h$)
Applications

• 2010: DCAC or DB-SRA applied to 50 species/stocks.

• 2013: XDB-SRA and XSSS applied to 8 species in 2013

• 2015: More applications...
Ongoing research & development
Comparing parameterization: productivity

flatfish

rockfish
Improving inputs: parameters

**Thorson et al. 2012**

\[ \frac{S_{B_{MSY}}/S_{B_0}}{F_{MSY}/M} \]

**Zhou et al. 2012**

Probability density for different species.

**Hamel in review**

**Cope et al. in review**

Depletion vs. Vulnerability graph.
Improving inputs: indices

- Commercial indices
  - GLMM software

- Recreational indices
  - No survey for nearshore stocks (yet)
  - Dockside sampling collects aggregated (trip-level) catch, effort, & location information
  - Created relational databases for OR & CA onboard CPFV observer programs (Monk et al., 2013, in press)
  - Analysis underway of drift-level data in relation to habitat data for state waters (Monk et al., in prep.)
Testing methods: Simulation testing

Wetzel & Punt 2011

Depletion Year

Testing methods: Simulation testing

Wetzel & Punt 2011

Wetzel and Punt in review

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Performance of Data-Limited Models: “Precautionary” stocks (50-100% $B_{MSY}$)

- Relative to average catch method, DCAC and DB-SRA reduce the probability of overfishing, while increasing or maintaining long-term yield.
- Dynamic methods further improve performance (e.g. XDB-SRA & XSSS).

Performance of Data-Limited Models: “Overfished” stocks (<50% $B_{MSY}$)

- Reduction in POF is less dramatic when applied to severely depleted stocks
- Long-term yield is consistently higher than average catch
- Take-home message: simple models are easy to apply, and perform better than average catch

Comparing methods: BASI approach

rockfish

flatfish

roundfish

elasmobranch
Comparing inputs: BASI approach

Stock status

Cope et al. in review
Strengths

• Provide OFL and/or status when data limited
• Response: reactive to need for alternative analyses
• Increase throughput
  • Non-assessed stocks
  • Stocks previously assessed & of low priority
• Already applied in management
• Proactive
  • Improving methods
    • Better input priors
    • Modelling enhancements
    • Management applications
• Testing methods
  • Simulation testing
  • BASI comparisons
• Developing new methods
Challenges & Solutions

• Resource limitations remain
  ▪ Continued method exploration and development
  ▪ Target data collection (e.g., indices)

• Large uncertainty in catch recommendations
  ▪ Improve prior on model input values
  ▪ Increase data in assessment (e.g., 1 year length compositions)

• Which stock category to apply?
  • Constraining catch and more available data
    ▪ Prioritize “fuller” stock assessment

• MSA and data-limited toolbox
  ▪ Explicit recognition in MSA/National Standards
  ▪ “Living” TORs